BRITISH COLUMBIA ACID MINE DRAINAGE TASK FORCE

Canada

BC

1989/1990

Annual Report

BRITISH COLUMBIA ACID MINE DRAINAGE TASK FORCE

AUGUST, 1990

91-00540/

Canadian Cataloguing in Publication Data

British Columbia Acid Mine Drainage Task Force
Annual report. -- 1989/1990-

Annual.
Report year ends Aug. 31st.
ISSN 1181-9294 = Annual report - British Columbia Acid Mine Drainage Task Force.

1. British Columbia Acid Mine Drainage Task Force - Periodicals. 2. Acid mine drainage - British Columbia - Periodicals. 3. Mines and mineral resources - British Columbia - Waste disposal - Periodicals.

TD899.M5B74 622'.5'09711 C90-092260-5

Table of Contents

	Page
1. Introduction by Ralph McGinn, Steering Committee Chairman	i
2. Introduction by Ron Hillis, Technical Committee Chairman	i
3. Prediction Prevention Subcommittee 1989/1990 Projects	1
Prediction: Open Pits (Equity Silver)	1
Underwater Disposal of Waste Rock and Tailings	2
Diagenesis of Aquatic Tailings (Howe Sound)	3
Subaerial Tailings Disposal	4
Blending and Segregation (Kutcho Creek)	5
New Projects 1990/1991	6
4. Treatment and Control Subcommittee 1989/1990 Projects	7
Waste Dump Hydrogeochemistry (BHP-Utah Island Copper Mine)	7
Gibraltar AMD Model	8
Evaluation of the Effectiveness of AMD Treatment Measures at Mount Washington	9
Waste Rock Treatment (Dry Covers)	10
Constructed Wetland (Bell Mine)	11
New Projects 1990/1991	12
5. Monitoring Subcommittee 1989/1990 Projects	13
Optimum Sampling Frequency	13
Biological Monitoring of AMD	14
Aquatic Invertebrate Monitoring	15
AMD Sediment Monitoring	16
New Projects 1990/1991	17
6. Summary of Expenditures	18
7. Proposed Program for 1990/1991	19
8. BCAMD Task Force Structure	20

1. Introduction by Ralph McGinn, *Steering Committee Chairman*

The British Columbia Acid Mine Drainage (BCAMD) Task Force is pleased and proud to present its first annual report. The report consists of reviews of the 1989/1990 Task Force projects and brief summaries of the 1990/1991 projects. It also includes annual accounting tables and information on the available projects in print. On behalf of the entire Task Force, I would like to say that we are proud of our initial accomplishments toward understanding and solving the problems of Acid Mine Drainage.

I would also like to personally thank the members of the Task Force who have keenly participated in establishing a very dynamic group. I know that a large percentage of the effort by individuals was freely given personal time, and their dedication to the Task Force shows up in the quality and quantity of the successful projects completed. It is evident that British Columbia is on the leading edge of new developments in solving this major environmental problem.

2. Introduction by Ron Hillis, *Technical Committee Chairman*

The BCAMD Task Force is a joint committee consisting of members from government, industry, and academia established three years ago. Its objectives are to find economic and effective solutions for the prediction, prevention, treatment, and control of acid mine drainage (AMD), and to transfer the knowledge to mining companies, consultants, and regulatory agencies so that the province's mineral resources are developed in an environmentally sound manner.

During the first year, the task force developed an information database on the state of affairs of acid mine drainage in British Columbia. Research priorities were developed, and in the second year funds were obtained to produce the "Acid Rock Drainage Technical Guide". This guide was published in August, 1989 and is available from "Crown Publications" (546 Yates Street, Victoria, B.C. V8W 1K8). Since the publication of the guide, courses have been offered in Vancouver and other areas of Canada, and even in Indonesia, based on its contents. The guide is designed to provide information on acid mine drainage processes and guidance on technology application.

Funds were made available through the Federal/Provincial Mineral Development Agreement (MDA) to allow some of the research projects to start. Fourteen projects were initiated in 1989, and in 1990 some of these projects will continue with the addition of several others. The Task Force is budgeting for approximately one million dollars for 1990, with the majority of the funding coming from Industry.

Coordinating the research and maintaining the data base are of top priority; therefore, a permanent position has been established at U.B.C. in the Department of Mining and Mineral Process Engineering. Funding for this chair has been provided by the B.C. Government and a well known B.C. mining company. This position, along with an Advisory Board made up of representatives from Government, Industry, and consulting firms, will be appointed by the Autumn of 1990.

In the third year of its existence, the BCAMD Task Force has accomplished a great deal. It has heightened acid mine drainage awareness, collected together in the technical guide the best understanding of acid mine drainage available, and made it accessible to all people involved in mineral development. The many research projects that have already been completed and that are presently underway will lead to a further understanding of the technical issues associated with AMD and possibly some solutions. As we become more aware of the risks involved in mineral development from an environmental point of view, we will be better prepared to deal with them from both an engineering and an economic point of view.

What the Task Force has not done, however, is to find a solution to the AMD problem, and if further mineral development is to occur in B.C. and other areas of the world, the mining industry will have to demonstrate that it knows how to handle this problem. We must, therefore, continue to support the Task Force's efforts and be actively involved. It should also be mentioned that the national MEND (Mine Environment Neutral Drainage) program has been involved in review of the program here in B.C., and where possible, activities have been integrated.

3. Prediction Prevention Subcommittee Projects

Project Name:	**Prediction: Open Pits (Equity Silver)**
BCAMD Number:	1.15
Consultant:	Morwijk Enterprises Ltd.
Budget:	MDA $20,850
	Equity $33,000

Objectives

This project was designed to assess the existing data at Equity Silver for the prediction of AMD from open pits containing acid generating material, and to develop and report on a computer model that would simulate and predict the potential for acid drainage from mine walls in open pits following closure.

Results

The report titled "Acid Drainage From Mine Walls: The Main Zone Pit At Equity Silver Mines" consists of a literature review; an evaluation of site data; a predictive model of AMD during operation, flooding, and after decommissioning; and a set of recommendations for further studies and for draft criteria of pit abandonment. The report is presently in press.

MINEWALL, a mathematically simulating computer program, was developed based on conceptual models that accounted for water movement, acid generation, acid neutralization, and metal leaching through time within a mine. MINEWALL was applied to the Main Zone Pit using measured and estimated data. The program predicted the Main Zone Pit would remain non-acidic throughout decommissioning, except for an initial mild acid flush at the beginning of flooding.

Further studies were recommended to Equity for improving the reliability of predictions during decommissioning, and to regulatory and research agencies for improving the general understanding of the critical processes that regulate water chemistry during open-pit operation and decommissioning. Recommendations for draft criteria of pit decommissioning were also proposed. This included criteria for pre-mining investigations of open pits, criteria during operation, and criteria for decommissioning. The capability to evaluate and predict the water-quality impacts of open pit mines has been greatly enlarged because of this project.

Project Name:	**Underwater Disposal of Waste Rock and Tailings**
BCAMD Number:	2.30
Consultant:	Rescan Environmental Consultants
Budget:	MDA ..... $49,900 CANMET ..... $20,000 Environment Canada $34,860

Objectives

This study was the second year of a possible four year project aimed at evaluating the effectiveness of underwater disposal of reactive waste rock and tailings, and at determining the criteria for environmentally safe disposal methods of reactive mine wastes in fresh water environments.

Results (1988)

By minimizing exposure to oxygen, subaqueous disposal practices were found to look promising in suppressing acid generation; however, it was concluded that further studies would be needed to understand the conditions under which it would be successful. The June 1989 report titled "Subaqueous Disposal of Reactive Mine Wastes: An Overview" is available upon request from MEMPR, Engineering and Inspection Branch, in Victoria.

Results (1989)

During 1989 the study was incorporated under the MEND Program to evaluate a number of sites across Canada. The report titled "Geochemical Assessment of Subaqueous Tailings Disposal in Buttle Lake, British Columbia" was the BCAMD Task Force contribution to the project and presents the results of the first detailed study of the distributions of metals in both the solid phases and interstitial waters of the abandoned tailings deposit in Buttle Lake. The report concludes that the buried tailings in the south basin of Buttle Lake are only having a negligible impact on the water quality of the area. The Buttle Lake report is currently in press.

1990/1991 Phase

The third phase of this project supports the continued assessment of the effectiveness of underwater disposal of acid waste rock and tailings for the prevention of AMD. It also involves the development of criteria for the safe disposal of mine wastes in freshwater environments. Tasks include conducting water quality, geochemical, and biological assessments of Benson Lake, and preparing a report that will provide new data on the behavior of acid wastes stored under water and useful information for the safe disposal of mining wastes in freshwater environments.

Project Name:	**Diagenesis of Aquatic Tailings (Howe Sound)**
BCAMD Number:	2.31
Consultant:	Karen Drysdale, U.B.C.
Budget:	MDA ..... $4,000 MEMPR $6,000

Objectives

This project investigated the long term reactivity of tailings derived from sulphide-rich ores when disposed of in a marine environment, and the potential mitigating effects of burial by natural sedimentation on the release of toxic metals by tailings in a marine environment.

Results

The findings, as of the March 1990 progress report titled "Geochemical Behavior of a Buried Marine Mine Tailings Deposit, Howe Sound", are as follows: Surface enrichments are being diluted by natural sedimentation from the Squamish River. Tailings are largely contained within the upper basin and virtually absent in the lower basin. (A sill separates the upper basin from the lower basin and from the rest of the sound). Oxygen diffusing into sediment from the overlying water is completely consumed by 7 cm depth in the lower basin and by 3 cm in the upper basin. It is probable that the added organic load from log-booming and pulp mill waste contributes to the increasing severity of the oxygen depletion in the upper basin. Dissolved sulfides are virtually absent, despite active sulfate reduction close to the sediment/water interface. The presence of the thin oxygenated layer indicates that the bulk of the metal-rich tailings deposit lies within the sulfate reducing zone, which is likely to render it generally unreactive and insoluble.

The final report, which will show if there is a flux of trace elements from the sediments and whether it exceeds that which is naturally occurring, will be completed in the form of a U.B.C., Department of Oceanography, M. Sc. Thesis by August, 1990.

Project Name:	**Subaerial Tailings Disposal**
BCAMD Number:	2.40
Consultant:	Linda Broughton, U.B.C.
Location:	Westmin Resources, Myra Creek
Budget:	Environment Canada $10,000

Objectives

This was the second year of a three year plan designed to determine the effectiveness of the subaerial tailings disposal system as a mechanism for the prevention of acid mine drainage, and to investigate the factors that control the initiation and extent of acid generation in high sulphide tailings at field scale.

Results

Results of the first two years of this project, which was jointly conducted by Environment Canada and Westmin Resources, have shown that simple sampling techniques along with a limited field and laboratory testing program provide valuable information on factors that control acid generation in a tailings facility. The 1988 program consisted of sampling of surface waters, sampling of surface solids from both fresh and exposed tailings, and test pit sampling to develop depth profiles in the tailings mass. A report on work done in 1988 is available from Environment Canada.

During 1989 the progression of oxidation and contaminant transport in the "old" layer of tailings was assessed, and the extent of acid generation and effect of the "new" covering layer of tailings was measured. These results will assist the design of other subaerial tailings facilities to limit acid production, provide useful input parameters for modelling the performance of a cover design, and indicate the length of time the tailings can be left exposed without encountering significant acid generation and contaminant migration.

1990/1991 Phase

The final year of this project consists of an assessment of the subaerial method of tailings disposal to determine if it enhances or reduces the rate of acid production or contaminant release, and if it hinders the rate of contaminant migration. The results will be in the form of a U.B.C., Department of Mining and Mineral Process Engineering, M. A. Sc. Thesis by Ms. L. Broughton, which will summarize and describe the results of field work conducted during the summer of 1989. The thesis will include an interpretation of data, an evaluation of trends in site geochemistry (with particular reference to acid generation rates and the effects of oxygen diffusion and water flow on oxidation rates), and a comparison to results from previous work. A laboratory study of zinc dissolution from both fresh and aged tailings will also be conducted.

Project Name:	**Blending and Segregation (Kutcho Creek)**
BCAMD Number:	2.60
Consultant:	Rescan Environmental Consultants
Budget:	MDA ..... $ 30,000
	Sumac Mines $110,000

Objectives

This study was the second year of a three year project aimed at evaluating the effectiveness of the techniques of segregating and blending acid generating waste rock and alkaline material as a method of preventing or controlling AMD.

Results

The first year of the Kutcho Creek Project, which involved humidity cell testing and petrographic examinations of the footwall pyritic tuff, indicated that sulfides in the footwall waste rock oxidize rapidly and are potentially acid generating. The hanging wall rock, however, is potentially acid consuming.

Results from the three 20 tonne field test plots that were constructed and implemented in 1989 are not yet available. Field scale test plots were set up to evaluate blending footwall and hanging wall wastes. Parallel laboratory humidity tests, however, showed reduced sulfate levels and metal concentrations, which indicates that blending over the short term minimizes acid generation. Acid-base accounting tests were also performed, and it was discovered that in the early stages of mine development, it may be necessary to mix limestone with the waste rock piles to increase the overall neutralization potential.

The "Kutcho Creek Project Acid Generation Testwork Phase II" report is in press.

1990/1991 Phase

The third and final year of this program includes monitoring drainage from the three test piles in the specially prepared test boxes and preparing a final report on the project. The report will include an evaluation of the success or failure of the technique of blending and segregating at Kutcho Creek. If successful, it will allow the property to be developed in an environmentally acceptable manner.

New Projects 1990/1991

Project Name: **Cinola Gold Project Kinetic Tests (Waste Rock Pads)**
BCAMD Number: 1.30
Consultant: Norecol Environmental Consultants

This is the first year of a three year project designed to characterize acid generation trends over six years (three past years completed) in waste rock pads and apply the results to modelling of waste rock dump acid generation processes. Objectives include evaluating the success of calcareous rock mixing (limestone) in the leach columns, and characterizing material that has undergone three years of weathering in humidity cells. Major tasks involve analyzing archived leachates from the existing limestone columns, concluding the humidity cell tests, and initiating monthly monitoring of waste rock pads at the site.

Project Name: **Compile Prediction Rules**

This study compiles the rules, tools, and "tricks of the trade" currently used by researchers, regulatory agencies, consultants, and the mining industry for AMD prediction. Its objective is the development of a decision flow chart to interpret AMD prediction data. It has been proposed that the project be conducted jointly by Environment Canada and a contractor. Tasks include conducting a literature review to identify any approaches for interpretation of prediction data (including common approaches used in the coal mining sector); interviewing key researchers in B.C., Canada, the U.S. and Australia; and assembling all approaches into a complete report including decision trees as appropriate. This project is not yet underway.

Project Name: **Compile AMD Prediction Data**

The main objectives of this study include improving the existing BCAMD database by adding prediction data for new mine projects in B.C. since 1980; analyzing these data to determine common trends or important differences that may aid future prediction; and, based on the proceeding, recommending improved approaches for prediction. Tasks involve reviewing all available prediction studies conducted for new mine projects in B.C. since 1980 using the Mine Development Review Process reports and compiling the information; creating an appropriate database system; and analyzing the data for important trends. Results will include an improved BCAMD database available for industry, government, researchers, and consultants interested in the prediction of acid mine drainage; a user's manual for the database; and a report interpreting the data. This project is not yet underway.

4. Treatment and Control Subcommittee Projects

Project Name:	**Waste Dump Hydrogeochemistry (BHP-Utah Island Copper Mine)**
BCAMD Number:	3.10
Consultant:	Mike Li, U.B.C.
Budget:	MDA ..... $25,000 BHP-Utah $60,000

Objectives

This project was designed to provide information leading to AMD control measures by determining the hydrogeochemistry of a waste dump at Island Copper through dump drilling, sampling, geochemical analysis, instrumentation, and water quality monitoring. Specific objectives included defining the spatial distribution of acid-generating and acid-consuming waste rock through a drilling program; defining the saturated and unsaturated ground water flow regime within the dump; developing a waste dump hydrological computer model; and defining and monitoring variations in sub-surface water quality.

Results

Work completed to date includes drilling of seven monitoring wells plus three pressure probe wells on the dump; installation of temperature probes, gas monitoring tubes, ground water level probes and pressure probes; acid-base accounting on the drill cuttings; retrieval of the dump building history; acquisition of three sets of monitoring readings; and calculation of physical parameters of the dump. The April, 1990 interim report is based on monitoring results obtained from October, 1989 to February, 1990, and involves some theoretical speculations.

Monitoring data reveal that: the dump has probably reached a steady state; temperature changes are solely due to the change of ambient temperature; where oxygen concentration increases or carbon dioxide concentration decreases, Acid Producing Potential very likely increases; the dump material has a high heat preserving capacity; the dump temperature may be affected by some diffusive or convective cold air current travelling along the interface of the dump and the original ground; heat generated by sulfide oxidation contributed to the increase in the dump temperature; correlation between oxygen concentration, carbon dioxide concentration, and APP exists, and it is expected that there is some kind of correlation between APP and oxygen concentration and between APP and carbon dioxide concentration, but the monitoring data did not show this.

A final report in the form of a U.B.C., Department of Mining and Mineral Process Engineering, M. Sc. Thesis by Mike Li will be produced.

Project Name:	**Gibraltar AMD Model**
BCAMD Number:	3.20
Consultant:	Klohn Leonoff Limited
Budget:	MDA $15,140
	Gibraltar $14,800

Objectives

This was the first year of a five year project designed to evaluate and model AMD from waste rock dumps at Gibraltar and lead to the prediction of the effect of leaching activities on long term water quality following closure. Specific objectives included evaluating the success of the pre-mine AMD prediction work and assessing the effect of rock mineralogy, mining practices, and hydrological conditions; assessing the effect of bioleaching on the long term acid-generating potential of dumps through models; verifying models through monitoring upon completion of economic leaching; and producing a report that details the findings of the study.

Results

The plans for 1989/1990 were to conduct a literature search of other bioleach operations; to review and assess all data on prediction, mineralogy, water quality, and other data related to Gibraltar; to prepare recommendations for further work to acquire additional data for long term prediction; and to prepare a report. The project was initiated in early 1990 and a project report will be produced and printed by September, 1990.

1990/1991 Phase

The second year of this project will continue last year's project and will include the added objective of modelling treatment alternatives designed to reduce the effects of long term AMD generation. First phase results will generate the second phase, but it is anticipated that the second phase will involve designing and implementing additional column leaching studies that either enhance recovery of copper or prevent leaching. A hydrogeological investigation of the waste rock dumps is also planned to facilitate interpretation of column leaching studies.

Project Name:	**Evaluation of the Effectiveness of AMD Treatment Measures at Mount Washington**
BCAMD Number:	3.30
Consultant:	MLC Construction; Steffen Robertson and Kirsten
Budget:	MDA $5,500

Objectives

The objectives of the 1989 reclamation work at Mount Washington were to evaluate the effectiveness of the till cover in controlling air and water movement to the dump materials and in controlling the release of AMD; and to make this experience applicable to other sites.

Results

During 1989 the glacial till blanket construction phase was completed, along with the construction of a 310 meter diversion ditch and the installation of fourteen piezometers. Seeding and fertilizing of the waste dump was completed, and a program was set up to monitor the physical and chemical hydrogeology of the mine site and waste dump and to evaluate the effectiveness of the reclamation activities already undertaken. The construction work cost $423,000 and was funded through the MEMPR operating budget.

Significant reduction has not yet been obtained in the level of dissolved copper emanating from the site; the blanket of mine waste remaining on the pit floor is a major source of acidity and copper; the effectiveness of the glacial till cover on the East Dump has not been proven or disproved, due to the impact of drainage from the pit on the East Dump; the blanket of mine waste is subject to an unusually high and variable water table that is considered to significantly increase the production of acid and metals; deep groundwater is not contaminated; and, the mine site will continue to generate unacceptably high levels of acid and copper until the blanket of mine waste in the pit is treated.

1990/1991 Work

This year's work at Mount Washington is designed to protect reclamation efforts against erosion, to obtain improved information on runoff and water quality for determination of AMD mechanisms in the pit, and to determine if cleaning of bedrock in the pit is a viable control technique. Contract work this year involves excavating waste, cleaning bedrock in the test area, installing standpipes in waste material in the pit, and upgrading of weirs. Monitoring work this year includes reading weirs and water qualities, which will result in fine-tuning of the model for acid generation in the pit area and East Dump toe. Results of the monitoring program will be included in a report which will detail requirements for cleaning the pit in 1991 and assess the feasibility of neutralizing East Dump drainage.

Project Name:	**Waste Rock Treatment (Dry Covers)**
BCAMD Number:	3.40
Consultant:	Northwest Geochem
Budget:	MDA $30,000
	Westmin Resources $30,000

Objectives

This was the final year of a three year program designed to assess the acid generation and hydrogeology at the Westmin Myra Falls waste rock dump and to evaluate novel and cost-effective approaches for preventing AMD from the dump. Specific objectives included testing solidified mine waste material, such as waste water tailings, as sealants to minimize moisture and air transfer for AMD generating waste rock dumps, and evaluating the use of alternative bactericides to reduce the activity of *Thiobacillus ferrooxidans*.

Results

The bactericidal approach evaluation was terminated when results from the waste rock dump characterization indicated that acid generation control at depth was required. Five out of more than 105 solidification mixtures composed mainly of mine waste water sludge and mine tailings were field tested for strength, setting times, leaching, and permeability; four were seen to be physically and chemically stable. This approach of using a cementitious solidification mixture incorporating mine waste materials for use as a waste rock dump surface sealant and grouting matrix was found to be the most promising method for reclamation efforts.

The Westmin Resources Ltd. report titled "Hydrogeological Assessment and Development of AMD Control Technology for Myra Falls Waste Rock" is in press.

1990/1991 Phase

Additional work was proposed and accepted by the Task Force. This year's program evaluates application techniques for sealant materials and seeks to develop environmentally safe disposal methods of waste treatment sludge. The main tasks involve conducting pilot scale tests at a materials testing laboratory; field scale application at Westmin; and the continued evaluation and development of a cementitious mixture for the disposal of treatment sludge wastes.

Project Name:	**Constructed Wetland (Bell Mine)**
BCAMD Number:	3.52
Consultant:	Gormely Process Engineering
Budget:	MDA $25,000
	Noranda $54,910

Objectives

Wetlands may be one of the best methods for the long term low cost treatment of AMD. This was the first year of a four year project proposed to design, construct, and monitor the performance of a wetland as a downstream passive treatment system for AMD at Bell Copper Mine. Specific monitoring objectives were to include assessing the efficiency of the wetland for metal removal on a seasonal basis, determining the sensitivity of the system to fluctuating flows and metal concentrations, determining the capacity of the wetland to absorb metals, and assessing the stability of the precipitated metals.

Results

A wetland was designed by Gormely Process Engineering, and the impoundment was constructed with supervision and materials supplied by Noranda Bell.

1990/1991 Phase

This year's tasks consist of establishing the biological components of the wetland and operating the wetland to establish a control situation. This project will be fully documented in the form of a progress report once the wetland has been tested and operated for one season.

New Projects 1990/1991

Project Name: **Britannia Mine — Toxic Leachate**
BCAMD Number: 3.31
Consultant: Steffen Robertson and Kirsten

This is the first year of a possible multi-year project designed to find a solution to treat, reduce, or eliminate acid mine drainage at Britannia Mine from entering Howe Sound. Tasks involve conducting a literature search of information dealing with discharge from Britannia Mine; critiquing the present system of diverting mine water to the 4100 level, and reporting on the effectiveness of the present treatment facility; presenting recommendations for a system of monitoring of copper level discharges; researching and reporting on the current technologies and estimated costs for the treatment and removal of copper in solution; and proposing possible long-term solutions to reduce AMD generation at the mine site.

5. Monitoring Subcommittee Projects

Project Name:	**Optimum Sampling Frequency**
BCAMD Number:	4.10
Consultant:	Emily Robertson
Budget:	MDA $27,020

Objectives

This study was designed to determine optimum water quality sampling frequencies for effluent caused by AMD by evaluating four of the most extensive water quality data sets associated with AMD in British Columbia. Specific objectives included determining an optimum water quality sampling frequency for each major variable or group of variables associated with AMD, and determining if correlations exist between major variables for both treated and untreated AMD contaminants and those parameters such as pH or conductivity that are amenable to continuous monitoring techniques.

Results

Results in the form of a report will include a review of the main literature on sampling theory, an evaluation of monitoring programs at several mine sites in British Columbia, an identification of deficiencies in current programs, and recommendation strategies for monitoring program designs.

Project Name:	**Biological Monitoring of AMD**
BCAMD Number:	4.20
Consultant:	E.V.S. Consultants Limited
Budget:	MDA $20,530

Objectives

This study was designed to determine the most effective methods for biological monitoring of AMD by reviewing existing methods and assessing and recommending the most effective techniques.

Results

This study found that a variety of indicators are suitable for detecting impacts of AMD, but few indicators have been linked to chronic whole organism responses. The most promising and proven biological monitoring techniques, however, include benthic community responses; growth and reproductive parameters of fish populations; survival in a designated zone of impact; and other changes at the individual, biochemical level. It was determined that no single approach to the problem of biological effects monitoring will completely satisfy the needs of the BCAMD Task Force. The most cost-effective approach to assessing ecosystem health in waters affected by AMD was found to involve a multidisciplinary, "top-down" approach, which relies on the detection of impacts before they become irreversible.

The final report for this project titled "Literature Review for Biological Monitoring of Heavy Metals in Aquatic Environments" is presently in press.

Project Name:	**Aquatic Invertebrate Monitoring**
BCAMD Number:	4.30
Consultant:	Limnotek Research and Development Inc.
Budget:	MDA $40,000
	MOE $13,100

Objectives

This was the first year of a possible three to four year research project aimed at evaluating a trough apparatus for measuring the environmental effects of dilute AMD on aquatic invertebrates. The main objective was to construct a ten flow-through trough apparatus and to test it through an initial run using a preselected concentration of treated AMD.

Results

The results showed that the experimental approach of using a mesocosm apparatus was highly sensitive and yielded analyses of variance with high power. The study showed conclusively that at the operational 10% AMD dilution rate, the addition of treated AMD to Foxy Creek did not affect the abundance or composition of periphytic algae or benthic aquatic insects. The apparatus was observed to be a powerful tool capable of accurately determining ecosystem response curves for effluent discharges during mine operations or at closure. It was also found to be ideal for exploring alternative AMD treatment strategies at specific sites.

The progress report titled "The Effect of Treated Acid Mine Drainage on Stream Macroinvertebrates and Periphytic Algae: An In Situ Mesocosm Experiment" is in press.

1990/1991 Phase

The second year's objectives are to use the trough apparatus by exposing benthic invertebrates and fish to preselected concentrations of dilute AMD, and to evaluate invertebrate community impacts and metals uptake by fish. Tasks consist of re-installing the apparatus at Equity Silver; operating it by using dilute AMD as the test contaminant; collecting invertebrates, monitoring fish tanks, servicing the instruments, and preparing the samples for analyses; and writing a progress report that describes the results of this program.

Project Name:	**AMD Sediment Monitoring**
BCAMD Number:	4.40
Consultant:	E.V.S. Consultants Limited
Budget:	MDA $5,000

Objectives

This project was designed to review all of the available literature pertaining to sediment monitoring techniques and to recommend their relevance and applicability as a means of measuring the impact of AMD.

Results

The draft report "Review of Sediment Monitoring Techniques" recommends the application of the Sediment Quality Triad approach for acid mine sites. This approach is an effects-based approach to evaluating and assessing pollution-induced degradation due to toxic sediments. It was developed to utilize three measures of sediment quality: sediment chemistry, which measures contamination; sediment bioassay, which measures toxicity; and biological community structure, which measures biological alteration. The Triad effectively combines the information from independent measures into an interpretive framework.

1990/1991 Phase

The second phase of this project is designed to broaden the scope of the E.V.S. draft document titled "Review of Sediment Monitoring Techniques" by including chemical characterization. The objectives of this further study include assembling relevant literature on chemical characterization of freshwater sediments, describing the utility of chemistry data in the determination of sediment contamination and its use in evaluating AMD impacts, and incorporating the information on chemical characterization into the draft document for future printing of the review.

New Projects 1990/1991

Project Name: **Ion Speciation Model**
BCAMD Number: 4.50
Consultant: CB Research International

This is a one year project designed with the objectives to obtain estimates of selected metal-NOM (natural organic matter) stability constants which will be used in a modified version of the speciation program MINEQL; and to calculate the most probable species for the selected metal ions using the modified version of MINEQL, and to predict changes in speciation due to simulated changes in water chemistry as a result of anthropogenic inputs. The output will include a report and a PC compatible floppy disc copy of the speciation model.

6. Summary of Expenditures

1989/1990

PROJECT NAME	MDA	INDUSTRY	MEMPR	CANMET	ENV.CAN	MOE	TOTALS
1.15 Prediction: Open Pits	20,850	33,000					53,850
2.30 Underwater Disposal of Waste Rock and Tailings	49,900			20,000	34,860		104,760
2.31 Diagenesis of Aquatic Tailings	4,000		6,000				10,000
2.40 Subaerial Tailings Disposal					10,000		10,000
2.60 Blending and Segregation	30,000	110,000					140,000
3.10 Waste Dump Hydrogeochemistry	25,000	60,000					85,000
3.20 Gibraltar AMD Model	15,140	14,800					29,940
3.30 Mount Washington Project	5,500						5,500
3.40 Waste Rock Treatment	30,000	30,000					60,000
3.52 Constructed Wetland	25,000	54,910					79,910
4.10 Optimum Sampling Frequency	27,020						27,020
4.20 Biological Monitoring of AMD	20,530						20,530
4.30 Aquatic Invertebrate Monitoring	40,000					13,100	53,100
4.40 AMD Sediment Monitoring	5,000						5,000
Totals	297,940	302,710	6,000	20,000	44,860	13,100	684,610

1988/1989

PROJECT NAME	MDA	INDUSTRY	MEMPR	CANMET	ENV.CAN	MOE	TOTALS
2.30 Underwater Disposal of Waste Rock and Tailings	49,980						49,980
2.40 Subaerial Tailings Disposal					10,000		10,000
2.60 Blending and Segregation	25,000	50,000					75,000
3.30 Mount Washington Project	8,170						8,170
3.40 Waste Rock Treatment	29,600	29,600					59,200
5.10 AMD Technical Guide	70,160				4,000		74,160
Totals	182,910	79,600			14,000		276,510

1987/1988

PROJECT NAME	MDA	INDUSTRY	MEMPR	CANMET	ENV.CAN	MOE	TOTALS
3.40 Waste Rock Treatment	25,000	30,000					55,000
AMD Questionnaire and Analysis	7,020					8,000	15,020
Totals	32,020	30,000				8,000	70,020

7. Proposed Program for 1990/1991

The total MDA funding available to the BCAMD Task Force is low for the 1990/1991 fiscal year, amounting to $136,000. However, the Industry, in anticipation of renewed funding in future years, has agreed to contribute a much larger proportion of the costs of projects that are jointly funded and company specific. Generic projects, however, which are associated with the Monitoring Subcommittee and the Prediction Prevention Subcommittee have been severely curtailed because alternative funding could not be found.

The available MDA funds were divided among the three subcommittees, and projects were priorized in the following way: projects which were initiated and are continuing are receiving funding; projects which have a company sponsor are receiving limited but reduced support; and generic projects, where it was felt that additional funding could be obtained from line agency budgets, are receiving limited support.

Three of the Task Force projects are also funded under a grant of $95,000 from the $500,000 Sustainable Environment Fund (SEF). These include the Mount Washington Project, Cinola Gold Project, AMD Sediment Monitoring Project, and Britannia Mine Toxic Leachate Project.

8. BCAMD Task Force Structure

Steering Committee:

Chairman: Ralph McGinn, *MEMPR*

Members:

Ishiro Abe, *Sumitomo Metal Mining Canada Ltd.*
Fred Claggett, *Environment Canada*
Ray Crook, *MEMPR*
John Errington, *MEMPR*
Bob Ferguson, *Ministry of Environment*
Keith Ferguson, *Environment Canada*
Ron Hillis, *BHP-Utah Mines Ltd.*
Robert Holmes, *Yukon Economic Development, Mines and Small Business*
Terry Johnson, *Mining Association of B.C.*
Garth Lee, *Maclaren Forest Products*
Mike Lipkewich, *Teck Corp.*
Peter Martin, *Equity Silver Mines Ltd.*
Tom Milner, *Quinsam Coal Ltd.*
Gordon Montgomery, *Resource Finance Corp.*
Jack Patterson, *B.C. & Yukon Chamber of Mines*
George Poling, *Mining Association of B.C.*
Jim Robertson, *Placer Dome*
Chris Sideco, *CANMET*
Ken Sumanik, *Mining Association of B.C.*
Brian Wilkes, *Ministry of Environment*

Technical Committee:

Chairman: Ron Hillis, *BHP-Utah Mines Ltd.*

Prediction and Prevention Subcommittee:

Chairman: Keith Ferguson, *Environment Canada*

Members:

Ishiro Abe, *Sumitomo Metal Mining Canada Ltd.*
Ed Dunn, *Kutcho Creek*
Jim Lant, *Crows Nest Resources Ltd.*
Dave Parsons, *Ministry of Environment*
George Poling, *Mining Association of B.C.*
Calvin Price, *Afton Operating Corp.*
Tom Schroeter, *MEMPR*
Harry Vogt, *Ministry of Environment*

Treatment and Control Subcommittee:

Chairman: John Errington, *MEMPR*

Members:

Murray Galbraith, *MEMPR*
Ross Gallinger, *Noranda Mines*
Bob Gardiner, *Cominco Ltd.*
Ron Hillis, *BHP-Utah Mines Ltd.*
Peri Mehling, *Environment Canada*
Bob Patterson, *Equity Silver Mines Ltd.*
Terry Roberts, *Ministry of Environment*
Ron Tessier, *Bell Mine*
Rudy Van Dyk, *Westmin Resources Ltd.*
Barry Weenk, *Gibraltar Mines Ltd.*

Monitoring Subcommittee:

Chairman: Brian Wilkes, *Ministry of Environment*

Members:

John Dick, *Ministry of Environment*
Lloyd Erickson, *Ministry of Environment*
Benoit Godin, *Environment Canada*
Ian Horne, *BHP-Utah Mines Ltd.*
Wayne Knapp, *Dept. of Fisheries & Oceans*
Ernst Leitz, *Westmin Resources Ltd.*
Bob Nijman, *Ministry of Environment*
Ken Sumanik, *Mining Association of B.C.*